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EXPERIMENTS ON THE MANURING OF TEA SEEDLINGS.

PREFATORY NOTE.

The following article describes the results of some experiments on the manuring of tea nurseries which were carried out during the year 1913 at the Tocklai Experimental Station with the object of investigating the relative value of different manures in promoting the development of tea seedlings.

This object is of direct practical importance owing to the fact that it is necessary in many cases to make nurseries, for purposes of infilling areas of tea, on soil far removed from a type suitable for the growth of seedlings. It is therefore of importance to determine how manures may be best employed for the purpose of promoting successful growth of young plants on exhausted or indifferent soil.

It is however of still greater importance, in connection with the whole problem of tea manuring, to determine the relationship between the manurial requirements of young plants and of mature bushes, and to obtain information as to the effect of each manurial ingredient in different forms on the growth of the young plant, and also to find out whether the same effect is produced on seedlings of different types.

The results of these preliminary experiments are difficult to follow, and are chiefly indicative of the importance of applying manurial ingredients in forms and proportions suitable to the particular type of soil and plant which is being treated. The deductions drawn from the individual experiments require confirmation from further experiments before it can be considered justifiable to make them the basis for practical recommendations, but they have been recorded here as fully as possible for the purpose of reference.

The work of carrying out these experiments fell chiefly to the Assistant Scientific Officer and the Entomologist.

G. D. H.

February 1914.

EXPERIMENTS ON THE MANURING OF TEA SEEDLINGS

BY

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The land at Tocklai on which these experiments were carried out had been for many years grazing ground, and before beginning these experiments it was covered with short grass and bushes of *Melastoma malabathricum*.

Prior to sowing the seed the land was deeply hoed once (on the 18th of December 1912) and afterwards light hoed (on the 29th of the same month). The beds were then prepared, each being 6′ × 12′. They were planted with germinated seed 9″ × 9″ apart (on the 11th of January 1913). The two kinds of tea seed planted were :—

Burma—representing the dark-leafed variety of indigenous tea; obtained from the Manipuri hills, and supplied by the Burma Tea Seed Syndicate.

Singlo—representing the light-leafed variety of indigenous tea; obtained from the Suffry garden of the Singlo Tea Company :

On the 24th of November, 1913 the plants from each plot were dug up, and, in order to determine the amount of their development, they were measured in respect of :—

(*a*) their girth at the ground level :
(*b*) their total height from ground level :
(*c*) their weight.

The work of measuring the very large number of seedlings which were grown in connection with these experiments made it impossible to carry out measurements to determine other data which would have been of interest, such for instance as the total volume occupied by the roots, the percentage of dry matter in each seedling, the total leaf area, the percentage composition of the mineral matter

in the seedlings, etc.; but the three measurements made were considered to give a fair idea of the total development of the seedlings as a potential factor in the production of a vigorous and healthy bush.

The following manures were applied :

Cattle manure
Lime
Sulphate of ammonia
Nitrolim
Superphosphate of lime
Basic slag
Sulphate of potash

In most cases these were applied in the form of mixtures which will be described in detail below, and they were put on to the plots in six applications of equal quantities. The total amount applied to each plot is expressed in terms of weight in lbs. per acre of the particular manures. In order to obtain information as to the most suitable relative proportions of each ingredient to apply, manurial mixtures were used containing these ingredients in varying proportions. In this way it is not possible to determine at once the *most suitable* relative proportions of the different manurial ingredients to apply in mixtures of manures for tea seedlings, but the results should serve as a guide in future experiments made to determine this point.

The first indication afforded by these experiments is that under one and the same set of conditions seed derived from two different sources does not develop equally well. This is shown by the following table :

TABLE I.

Unmanured plots.	Burmah.	Singlo.
Average weight of 100 plants.	130·22 oz.	127·02 oz.
Average diameter of stem of plant at the ground level.	0·17 in.	0·18 in.
Average height of plants above ground.	16·07 „	17·75 „

The Singlo plants had a much better appearance, but the Burmah plants grew more evenly.

The plots were so arranged that plants of one type when manured were compared with plants of the same variety from an unmanured plot. Three sets of observations only were made for the purposes of these experiments, namely, height of the plants above ground, diameter of the stem at the ground level, and total weight of the plants. Of these perhaps the greatest importance must be attached to the diameter of the plants, more especially when the seedlings are to be used in open spaces and not closely surrounded by full grown tea. When plants are required for planting in situations where each seedling is surrounded by plucked tea the early development in height of the seedling plant becomes an important consideration, yet even under such conditions it would seem to be desirable to use plants that have a comparatively large diameter of stem. Tall plants that have a thin stem are likely to be weakly.

The following table shews the average relative development expressed as a percentage of increase or decrease in respect of diameter at ground level, height above ground, and weight of the plants from the manured plots, compared with plants from the unmanured plots for each variety of tea.

TABLE II.

Manures, Rate of application per acre.	Burmah.						Singlo.					
	Diameter.		Height.		Weight		Diameter.		Height.		Weight.	
	Inc	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
Cattle manure 20 tons= 314 lbs. nitrogen 112 lbs. phosphoric acid. 184 lbs. potash.	37%	...	7%	...	18%	...	15%	...	11%	...	56%	

TABLE II—*continued.*

Manures, Rate of application per acre.	Burmah.						Singlo.					
	Diameter.		Height.		Weight.		Diameter.		Height.		Weight.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen Superphosphate of lime 672 lbs. = 122 lbs. phosphoric acid. Sulphate of potash 448 lbs. = 224 lbs. potash.	...	9%	9%	...	...	6%	15%	...	6%	...	65%	...
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen. Superphosphate of lime 168 lbs. = 30 lbs. phosphoric acid. Sulphate of potash 448 lbs. = 224 lbs. potash.	...	17%	...	17%	..	23%	.	13%	4%	...	0%	0%
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen. Superphosphate of lime 672 lbs. = 122 lbs. phosphoric acid. Sulphate of potash 112 lbs. = 56 lbs. potash.	...	7%	...	1%	..	2%	9%	...	16%	...	29%	...
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen. Superphosphate of lime 168 lbs. = 30 lbs. phosphoric acid. Sulphate of potash 112 lbs. = 56 lbs. potash.	...	15%	...	10%	...	18%	0%	0%	...	5%	...	7%

TABLE II—*continued.*

Manures, Rate of application per acre.	Burmah. Diameter. Inc.	Dec.	Height. Inc.	Dec.	Weight. Inc.	Dec.	Singlo. Diameter. Inc.	Dec.	Height. Inc.	Dec.	Weight. Inc.	Dec.
Nitrolim 503 lbs. = 90 lbs. nitrogen. Basic slag 280 lbs. = 30 lbs. phosphoric acid. Sulphate of potash 112 lbs. = 56 lbs. potash.	61%	...	.	6%	.	26%	...	6%	...	8%	...	7%
Nitrolim 125 lbs. = 20·5 lbs. nitrogen. Basic slag 1120 lbs. = 122 lbs. phosphoric acid. Sulphate of potash 448 lbs. = 224 lbs. potash.	13%	...	3%	...	9%	..	12%	...	..	4%	14%	...
Nitrolim 125 lbs. = 20·5 lbs. nitrogen. Basic slag 280 lbs. = 30 lbs. phosphoric acid. Sulphate of potash 112 lbs. = 56 lbs. potash	9%	...	.	6%	11%	..	18%	...	...	12%	58%	..
Nitrolim 125 lbs. = 20·5 lbs. nitrogen. Basic slag 280 lbs. = 30 lbs. phosphoric acid Sulphate of potash 112 lbs. = 56 lbs. potash.	17%	...	...	3%	...	8%	...	7%	1%	...	...	3%
Nitrolim 125 lbs. = 20·5 lbs. nitrogen. Basic slag 1120 lbs. = 122 lbs. phosphoric acid. Sulphate of potash 112 lbs. = 56 lbs. potash.	...	3%	...	7%	..	18%	...	...	0%	0%	4%	...

TABLE II—*concluded.*

MANURES, Rate of application per acre.	Burmah.						Singlo.					
	Diameter.		Height.		Weight.		Diameter.		Height.		Weight.	
	Inc.	Dec.	Inc	Dec.	Inc.	Dec.	Inc.	Dec.	Inc	Dec.	Inc.	Dec.
Sulphate of ammonia 112 lbs.= 20·5 lbs. nitrogen. Superphosphate of lime 672 lbs.= 122 lbs. phosphoric acid. Sulphate of potash 448 lbs.= 224 lbs. potash.	4%	...	10%	...	14%	...	22%	...	7%	...	36%	..
Sulphate of ammonia 112 lbs.= 20·5 lbs. nitrogen. Superphosphate of lime 168 lbs.= 30 lbs. phosphoric acid. Sulphate of potash 448 lbs.= 224 lbs. potash.	...	9%	...	4%	...	26%	0%	0%	3%	...	5%	...
Sulphate of ammonia 112 lbs.= 20·5 lbs. nitrogen. Superphosphate of lime 168 lbs.= 30 lbs. phosphoric acid. Sulphate of potash 112 lbs.= 56 lbs potash.	...	8%	...	1%	11%	..	15%	...	...	8%	7%	...
Nitrolim 503 lbs.= 90 lbs. nitrogen. Basic slag 1120 lbs.= 122 lbs. phosphoric acid. Sulphate of potash 112 lbs.= 56 lbs. potash.	64%	...	...	2%	...	16%	4%	...	..	15%	1%	...
Nitrolim 503 lbs.= 90 lbs. nitrogen. Basic slag 1120= 122 lbs. phosphoric acid. Sulphate of potash 448 lbs.= 224 lbs. potash.	8%	...	4%	...	9%	...	14%	...	...	9%	9%	..

The results of the experiments show that the same manurial mixture does not have the same influence upon the two varieties of tea. In the case of Burmah seed the manures have not produced any marked increase in *weight* or *height* whilst in some cases a considerable decrease is to be noted. The use of acid manures has resulted in a decrease in the *diameter of the stems* of the plants whilst by the use of basic manures a very noticeable increase has resulted.

The Singlo seed appears to respond more readily to the application of manures and in some cases a very considerable increase in the *weight* of the plants is to be noticed. Although the plants by manuring increased in *diameter of the stems* yet this increase is not so noticeable as in the case of the Burmah tea. But little effect upon the *height* of the bushes has resulted.

Before discussing the value of mixtures of artificial manures for inducing the good growth of seedling plants it must be pointed out that both with the Burmah and Singlo seedlings the use of cattle manure has resulted in perhaps the best general development of the plant. The relative proportions of nitrogen to phosphoric acid and potash in the cattle manure used were as :—

100 : 36 : 57.

and the actual quantities contained in 20 tons of the manure were :—

Nitrogen	314 lbs.
Phosphoric acid	112 „
Potash	184 „

The mixtures of artificial manures contained varying quantities of nitrogen, phosphoric acid, and potash, in order to ascertain the effect of various mixtures upon the development of the plants and to throw light on the most suitable total relative proportions for the three manurial ingredients.

The development of the plants in respect of diameter of the stems, height of the stems above ground, and weight of the plants has been recorded and we shall now proceed to determine from the results of the experiments the effect of the manures in these three directions.

BURMAH PLANTS.

DIAMETER OF THE STEM.

Acid manures (see Table III) :—The application of these has not resulted in the formation of plants having thick stems, for in only one instance has the plot which received manure produced plants having a greater diameter of the stem than the plants from the check plot, and even then the increment is but small.

It is secondly noticeable that phosphoric acid applied in this form appears to influence favourably the development of thick stems, for the thicker stems are without exception produced by mixtures which contain phosphoric acid in the larger of the two quantities used. The reverse seems to be the case with nitrogen for with one exception the mixtures containing nitrogen in the larger quantity are those which produce the greatest decrease in thickness of stem. In the experiment which forms the exception to this the smaller quantity of phosphoric acid was used and the larger quantity of potash and the presence of these manures in these quantities may account for the decrease in this case being sufficiently great to put this experiment out of its proper place as shewing the effect of nitrogen alone, for with regard to potash the results seem to indicate that the smaller quantity of this manure would probably be sufficient. For when nitrogen and phosphoric acid are present in the same relative quantities the larger quantity of potash produces a slightly greater diminution than the smaller quantity. A possible explanation of this is that if the smaller quantity of potash applied is sufficient for the needs of the seedlings any addition of potash to this quantity may actually have a detrimental effect as the result of its action on the soil; this effect is probably similar but more marked in the case of sulphate of ammonia. In the only case in which the plants shewed an increased development in thickness of the stem above the check plot as a result of manures, the mixture contained the large quantity of phosphoric acid, and the small quantity only of nitrogen. Any variation of the mixture appears to effect a depressing action upon the development of the plant in the direction under consideration. It is however noticeable that a diminution in the quantity of phosphoric acid applied results in the greatest diminution in the

thickness of the stems and this effect becomes most evident when both nitrogen and potash are added in the large quantities. It therefore would appear to be more necessary to avoid a large excess of nitrogen than of potash.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid, and potash which has given the best results was :—

100 : 530 : 1000.

A formula which provides a mixture in which the three ingredients mentioned above are present in the desired ratio is :—

Sulphate of ammonia	...	... 112 lbs.
Superphosphate of lime	...	... 672 „
Sulphate of potash	...	... 112 „

TABLE III.

Manures, Rate of application per acre.	Diameter of stems.	
	Increase.	Decrease.
Sulphate of ammonia 112 lbs. = 22·5 lbs. nitrogen ... Superphosphate 672 lbs. = 122 lbs. phosphoric acid... Sulphate of potash 448 lbs. = 224 lbs. potash	4%	.....
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 672 lbs. = 122 lbs. phosphoric acid... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	7%
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 672 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	......	9%
Sulphate of ammonia 112 lbs. = 22·5 lbs. nitrogen ... Superphosphate 168 lbs. = 30·5 lbs. phosphoric acid... Sulphate of potash 448 lbs. = 224 lbs. potash ..	.. ...	9%
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 168 lbs. = 30·5 lbs. phosphoric acid... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	15%
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 168 lbs. = 30·5 lbs. phosphoric acid... Sulphate of potash 448 lbs. = 224 lbs. potash ...	......	17%

Basic manures (see Table IV) :—The plots to which these manures were added have with one exception produced plants that

possessed a diameter of stem greater than the plants on the check plots. On two plots the plants had a much greater thickness of stem than on the remaining plots and in both these cases the manurial mixtures were in some respects similar to each other. They both contained a large quantity of nitrogen and a small quantity of potash. The plot that at the same time received the larger quantity of phosphoric acid was slightly better than the one receiving only the smaller amount but the difference in development of the plant was not marked. When however the quantity of nitrogen is diminished the development of the plant is much less pronounced and when this is combined with the larger quantity of potash a still further reduction in the thickness of the stem is to be noticed. The quantity of phosphoric acid does not appear to act as a controlling factor.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid, and potash which has given the best results was :—

100 : 125 : 59.

A formula which provides a mixture in which the three ingredients mentioned above are present in the desired ratio is :—

Nitrolim	... ...	503 lbs.
Basic slag	... ...	1120 "
Sulphate of potash...	... ...	112 "

It has however been pointed out that the use of the smaller quantity of phosphoric acid caused but a slight reduction in the diameter of the stems of the plants. And a manure which contained the three ingredients mentioned above in the following ratio :

100 : 33 : 63.

gave good results.

A formula which provides a mixture in which the three ingredients mentioned above are present in this ratio is :—

Nitrolim	... ...	503 lbs.
Basic slag	... ...	280 "
Sulphate of potash ...	... ...	112 "

TABLE IV.

Manures, Rate of application per acre.	Diameter of stems.	
	Increase.	Decrease.
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 1120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	64%	......
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	61%	......
Nitrolim 125 lbs. = 22·5 lbs. nitrogen. ... . Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	17%	......
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 1120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	13%	......
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	9%	......
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	8%	......
Nitrolim 125 lbs. = 22·5 lbs. nitrogen .. ... Basic slag 1120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	3%

HEIGHT OF PLANTS.

Acid manures.—(see Table V) :—Three of the mixtures employed gave rise to an increased length of stem but in only two cases was this increase of practical consideration. It is however to be noted that the two plots which produced the latter plants received the larger quantity of phosphoric acid. When this was reduced to the smaller quantity a decrease in the length of the plant took place and this reached a maximum when the larger quantities of nitrogen and potash were also used. In the two plots that gave rise to plants with a substantial increase in length not only was the larger quantity of phosphoric acid used but also the larger quantity of potash, though the effect of potash on the height of the seedlings remains rather obscure from these experiments.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid, and potash which has given the best results was :—

100 : 530 : 1000

A formula which provides a mixture in which the three ingredients mentioned above are present in the desired ratio is

Sulphate of ammonia	112 lbs.
Superphosphate of lime (18%)	672 „
Sulphate of potash	448 „

TABLE V.

MANURES, Rate of application per acre.	HEIGHT OF PLANTS.	
	Increase.	Decrease.
Sulphate of ammonia 112 lbs. = 22·5 lbs. nitrogen ... Superphosphate 672 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	10%	....
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 672 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	9%	......
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 672 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 112 lbs = 56 lbs. potash ...	1%	......
Sulphate of ammonia 112 lbs. = 22·5 lbs. nitrogen ... Superphosphate 168 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	......	8%
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen .. Superphosphate 168 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	.. ...	10%
Sulphate of ammonia 448 lbs. = 90 lbs. nitrogen ... Superphosphate 168 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	......	17%

Basic manures (see Table VI) :—The use of these manures does not materially affect the development of the length of stem of the plant. It will be noticed that in the majority of cases the effect has been one of depression and that an increase in the length of the stem has occurred in only two instances. The manurial mixture used in both these experiments contained the larger quantity of potash and either the larger quantity of nitrogen or phosphoric acid. It is of interest to note that comparatively short plants were obtained from the plot which received the larger quantity of potash together with the smaller quantities of nitrogen and phosphoric acid. Whenever the smaller quantity of potash was used a small development in length of the plants took place. It appears from the experiments that potash favourably affects the

development of height in the seedlings. No other conclusions can at present justifiably be drawn from them.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid, and potash which has given the best results was :—

(*i*) 100 : 33 : 250
(*ii*) 100 : 530 : 1000

Formulae which provide mixtures in which the three ingredients mentioned above are present in the desired ratios are :—

(*i*)	Nitrolim	503 lbs.
	Basic slag	280 „
	Sulphate of potash	448 „
(*ii*)	Nitrolim	125 „
	Basic slag	1120 „
	Sulphate of potash	448 „

TABLE VI.

Manures, Rate of application per acre.	Height of plants.	
	Increase.	Decrease.
Nitrolim 503 lbs.=90 lbs. nitrogen ... ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	4%	......
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... ... Basic slag 1120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	3%	......
Nitrolim 503 lbs.=90 lbs. nitrogen ... ... Basic slag 1120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	2%
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	.....	3%
Nitrolim 503 lbs.=90 lbs. nitrogen ... ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	6%
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	6%
Nitrolim 125 lbs.=22 5 lbs. nitrogen ... ... Basic slag 1120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	7%.

WEIGHT OF PLANTS.

Acid manures (see Table VII) :—Here again the use of acid manures has in only two cases resulted in the plants being heavier than those grown on the check plots whereas in three cases the plants weigh considerably less. It is evident from an examination of the table that the cases in which an increase in weight was obtained occurred when the larger quantity of phosphoric acid was used. The use of the smaller quantity of phosphoric acid in every case resulted in a very decided diminution in the weight of the plants.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid, and potash which has given the best results was :—

100 : 530 : 1000

A formula which provides a mixture in which the three ingredients mentioned above are present in the desired ratio is :—

Sulphate of ammonia	112 lbs.
Superphosphate of lime	672 „
Sulphate of potash	448 „

TABLE VII.

MANURES, Rate of application per acre.	WEIGHT.	
	Increase.	Decrease.
Sulphate of ammonia 112 lbs.=22·5 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid... Sulphate of potash 448 lbs.=224 lbs. potash ...	14%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	2%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid .. Sulphate of potash 448 lbs.=224 lbs. potash ...	......	6%
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	18%
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	23%
Sulphate of ammonia 112 lbs.=22 5 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	26%

Basic manures (see Table VIII) :—Some of these mixture have caused an increase to take place whereas the use of others o them has resulted in a very decided decrease in the weight of the plants. It is however clear from a study of the experimental data that this variation is controlled largely by the amount of potash used. In all cases where an increase has been obtained the larger quantity of this substance was applied, and in all cases where a decrease has taken place the smaller quantity was used. The plot on which grew the plants of heaviest weight received the smaller quantities of nitrogen and phosphoric acid. Provided that the larger quantity of potash is used no difference in the weight of the plants is noticed by increasing the quantity of either nitrogen or phosphoric acid.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid and potash which has given the best results was :—

100 : 120 : 1000

A formula which provides a mixture in which the three ingredients mentioned above are present in the desired ratio is :—

Nitrolim	125 lbs.
Basic slag	280 „
Sulphate of potash	448 „

TABLE VIII.

Manures, Rate of application per acre.	Weight.	
	Increase.	Decrease.
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	11%	......
Nitrolim 503 lbs. = 90 lbs. nitrogen .. ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	9%	......
Nitrolim 125 lbs. = 22 5 lbs. nitrogen ... ... Basic slag 1120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	9%	......
Nitrolim 125 lbs. = 22 5 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	8%

TABLE VIII—*continued.*

Manures, Rate of application per acre.	Weight.	
	Increase.	Decrease.
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 1120 lbs. = 122 lbs. phosphoric acid .. Sulphate of potash 112 lbs. 56 lbs. potash ...	......	16%
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 1120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	.....	18%
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	26%

SINGLO PLANTS.

DIAMETER OF THE STEM.

Acid manures (see Table IX) :—It will be at once noticed by an examination of the table that the use of acid manures has generally resulted in the development of plants with an increased thickness of stem. In only two cases however has the increase been great. The greatest diameter of the stem was attained by plants which received the smaller quantity of nitrogen. The use of a larger quantity of nitrogen has caused a diminution in the thickness of the stems. This will be noted in each case where the larger quantity has been employed. It is equally noticeable that phosphoric acid is a factor in the development of plant with thick stems. It is worthy of note that when the larger quantities of nitrogen and potash were used in conjunction with the smaller quantity of phosphoric acid the thickness of the stems of the plant was reduced materially below that of the plants on the check plots.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid and potash which has given the best results was :—

100 : 530 : 1,000

A mixture which provides the above mentioned three ingredients in the desired ratio is—

Sulphate of ammonia ...	... 112 lbs.
Superphosphate of lime (18%) ...	... 672 „
Sulphate of potash ...	... 448 „

TABLE IX.

Manures, Rate of application per acre.	Diameter of stems.	
	Increase.	Decrease.
Sulphate of ammonia 112 lbs.=22·5 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	22%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	15%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	2%	......
Sulphate of ammonia 112 lbs.=22·5 lbs. nitrogen .. Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	2%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid .. Sulphate of potash 112 lbs.=56 lbs. potash ...	0%	0%
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	13%

Basic manures (see Table XI) :—In only two cases has the use of a basic manure resulted in any decided increases in the thickness of the stem and in several cases the plants have developed poorly in this respect and compare unfavourably with plants from the check plots. The plants that have shewn the greatest increase in thickness have received as a manure the larger quantity of potash together with the larger quantity of either nitrogen or phosphoric acid. It appears probable that a mixture giving the larger quantities of all three would have given the best results. If both nitrogen and phosphoric acid are present in the smaller quantity, the potash being at the same time in the larger amount, a consider-

able reduction in the diameter of the stems is noticed. The results do not at first sight appear to give any definite information but it is evident that the relative proportions of the three ingredients, nitrogen, phosphoric acid, and potash exert a considerable influence upon the development of the plant. When the ratio of nitrogen to phosphoric acid is as 100 : 130 then the smaller the quantity of potash that is present, the better is the development of the plants in respect of thickness of stem. This being so it would be expected that if no potash were used a still further improvement would be attained. This was actually so as will be seen by the following table derived from the result of experiments.

TABLE X.

Nitrogen.	Ratio of ingredients.		Diameter of stems.	
	Phosphoric acid.	Potash.	Increase.	Decrease.
100	130	......	6%	......
100	130	0·60	3%	......
100	130	2·50	......	6%
100	130	1000	......	18%

It is however to be noted that the use of nitrogen and phosphoric acid in the above mentioned ratio did not give such satisfactory results as they did when applied in certain other proportions.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid and potash which has given the best results was :—

(*i*) 100 : 33 : 250
or (*ii*) 100 : 530 : 1000

The following formulae respectively provide manurial mixtures that contain the above three mentioned ingredients in the desirable ratio :—

I.	**Nitrolim**	503 lbs.
	Basic slag	280 „
	Sulphate of potash	448 „

or II. Nitrolim ... ... 125 lbs.
Basic slag ... ... 1,120 „
Sulphate of potash ... ... 448 „

TABLE XI.

MANURES, Rate of application per acre.	DIAMETER OF STEMS.	
	Increase.	Decrease.
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	14%	.....
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 1,120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	12%	......
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 1,120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 112 lbs = 56 lbs. potash ...	......	4%
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 1,120 lbs. = 122 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	6%
Nitrolim 503 lbs. = 90 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 112 lbs. = 56 lbs. potash ...	......	6%
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... ... Basic slag 280 lbs. = 30 lbs. phosphoric acid ... Sulphate of potash 448 lbs. = 224 lbs. potash ...	......	18%

HEIGHT OF PLANTS.

Acid manures (see Table XII):—Here again it will be noticed that the use of acid manures has resulted in the majority of experiments in an increased height of the plants. The results indicate that the larger quantities of phosphoric acid give the best results and that there is a decrease when the larger quantity of nitrogen is used. It is of interest to note that when both nitrogen and potash are present in the larger quantities and phosphoric acid in the smaller the least development of the plant has taken place and tnat the best results are obtained when phosphoric acid and potash are together in large quantities.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid and potash which has given the best results was :—

100 : 500 : 1000

This ratio is the same as is necessary for the development of plants with thick stems and consequently the same manurial mixture would be suitable.

TABLE XII.

Manures, Rate of application per acre.	Height of Plants.	
	Increase.	Decrease.
Sulphate of ammonia 112 lbs.=22·5 lbs. nitrogen ... Superphosphate 18% 672 lbs.=122 lbs. phosphoric acid ... ... Sulphate of potash 448 lbs.=224 lbs. potash ...	7%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	6%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 672 lbs.=122 lbs. phosphoric acid... Sulphate of potash 112 lbs.=56 lbs. potash ...	3%	......
Sulphate of ammonia 112 lbs.=22·5 lbs. nitrogen .. Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	3%	......
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	4%
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	8%

Basic manures (see Table XIII) :—The use of manures of this type has not only decreased the height of the plant but there is a noticeable tendency for the plants to develop with stems shorter than those of the plants on the check plots. In only one case has there been an increase in the height and these plants received an application of the smaller amounts of nitrogen, phosphoric acid and potash. If potash is used in the larger quantity decrease in the height of the plants is effected. This decrease is least noticeable when the phosphoric acid is used in the larger quantity.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid and potash which has given the best results was :—

100 : 130 : 250.

A formula which provides a mixture containing the above-mentioned three ingredients in the desired ratio is :—

Nitrolim	125 lbs.
Basic slag	280 „
Sulphate of potash	112 „

TABLE XIII.

Manures, Rate of application per acre.	Height of Plants.	
	Increase.	Decrease.
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	1%	......
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... ... Basic slag 1,120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	7%
Nitrolim 503 lbs.=90 lbs. nitrogen .. ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	8%
Nitrolim 503 lbs.=90 lbs. nitrogen ... ... Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	9%
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... ... Basic slag 1,120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	10%
Nitrolim 503 lbs.=90 lbs. nitrogen ... ... Basic slag 1,120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 112 lbs.=56 lbs. potash ...	......	13%
Nitrolim 125 lbs.=22·5 lbs. nitrogen ... .. Basic slag 280 lbs.=30 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash ...	......	14%

WEIGHT OF PLANTS.

Acid manures (see Table XIV) :—It will at once be noticed that the employment of this type of manure has in no instance brought about the development of bushes of smaller weight than those on the check plot. In several cases a very large increase has taken place. It was when the larger quantities of phosphoric

ıcid and potash were used that a large increase in weight took place. The use of the smaller quantity in all cases resulted in little or no ncrease and phosphoric acid and potash have evidently a definitely 'avourable influence on the development of weight. The greatest ncrease has taken place when the plot received the largest quantities of nitrogen, phosphoric acid and potash. A study of the results 'enders it evident that the relative quantities of the three ingredi-nts in the manurial mixture is an important factor in the develop-nent of the plants.

In the particular experiments under consideration the ratio of ıitrogen, phosphoric acid and potash which has given the best 'esults was :—

100 : 130 : 250.

A formula which provides a manurial mixture in which the three ngredients mentioned above are present in the desired ratio is :—

Sulphate of ammonia	...	... 448 lbs.
Superphosphate of lime (18%) ...		... 672 „
Sulphate of potash	...	... 448 „

TABLE XIV.

Manures, Rate of application per acre.	Weight of Plants.	
	Increase.	Decrease.
ulphate of ammonia 448 lbs.=90 lbs. nitrogen ... / uperphosphate 672 lbs.=122 lbs. phosphoric acid .. / ulphate of potash 448 lbs.=224 lbs. potash ...	65%	......
ulphate of ammonia 112 lbs.=22·5 lbs. nitrogen ... / uperphosphate 672 lbs.=122 lbs. phosphoric acid ... / ulphate of potash 448 lbs.=224 lbs. potash ...	36%	... ..
ulphate of ammonia 448 lbs.=90 lbs. nitrogen ... / uperphosphate 672 lbs.=122 lbs. phosphoric acid ... / ulphate of potash 112 lbs.=56 lbs. potash ..	29%	... ..
ulphate of ammonia 112 lbs.=22·5 lbs. nitrogen ... / uperphosphate 168 lbs.=30 lbs. phosphoric acid ... / ulphate of potash 448 lbs.=224 lbs. potash ...	5%	......
ulphate of ammonia 448 lbs.=90 lbs. nitrogen ... / uperphosphate 168 lbs.=30 lbs. phosphoric acid ... / ulphate of potash 448 lbs.=224 lbs. potash ...	0%	0%
ulphate of ammonia 448 lbs.=90 lbs. nitrogen ... / uperphosphate 168 lbs.=30 lbs. phosphoric acid ... / ulphate of potash 112 lbs.=56 lbs. potash ...	0%	0%

Basic manures (see Table XV) :—The use of these manures caused the plants to develop an increased weight in some cases and a decreased weight in others. The employment of the larger quantity of phosphoric acid was influential in producing greater development. No conclusion can be drawn from these experiments in regard to the influence of nitrogen and potash on the weight of the plants.

In the particular experiments under consideration the ratio of nitrogen, phosphoric acid, and potash which has given the best results was :

100 : 530 : 1,000

A formula which provides a mixture in which the three ingredients mentioned above are present in the desired ratio is :—

Nitrolim	125 lbs.
Basic slag	1,120 „
Sulphate of potash	448 „

TABLE XV.

MANURES, Rate of application per acre.	WEIGHT OF PLANTS.	
	Increase.	Decrease.
Nitrolim 125 lbs. = 22·5 lbs. nitrogen .. Basic slag 1,120 lbs. = 122 lbs. phosphoric acid Sulphate of potash 448 lbs. = 224 lbs. potash	15%	......
Nitrolim 503 lbs. = 90 lbs. nitrogen ... Basic slag 280 lbs. = 30 lbs. phosphoric acid Sulphate of potash 448 lbs. = 224 lbs. potash	9%	......
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... Basic slag 1,120 lbs. = 122 lbs. phosphoric acid Sulphate of potash 112 lbs. = 56 lbs. potash	3%	......
Nitrolim 503 lbs. = 90 lbs. nitrogen ... Basic slag 1,120 lbs. = 122 lbs. phosphoric acid Sulphate of potash 112 lbs. = 56 lbs. potash	1%	......
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... Basic slag 280 lbs. = 30 lbs. phosphoric acid Sulphate of potash 112 lbs. = 56 lbs. potash	......	3%
Nitrolim 503 lbs. = 90 lbs. nitrogen ... Basic slag 280 lbs. = 80 lbs. phosphoric acid Sulphate of potash 112 lbs. = 56 lbs. potash	......	7%
Nitrolim 125 lbs. = 22·5 lbs. nitrogen ... Basic slag 280 lbs. = 30 lbs. phosphoric acid Sulphate of potash 448 lbs. = 224 lbs. potash	......	14%

With the Singlo plants an experiment was made giving the same acid manure in different quantities in order to ascertain whether the actual amount of manure applied was sufficient.

TABLE XVI.

Manures, Rate of application per acre.	Diameter.		Height.		Weight.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
Sulphate of ammonia 448 lbs.=90 lbs. nitrogen ... ... Superphosphate 672 lbs.=122 lbs. phosphoric acid... ... ... Sulphate of potash 448 lbs.=224 lbs. potash	15%	...	6%	...	65%	...
Sulphate of ammonia 112 lbs.=22·5 lbs. nitrogen ... ... Superphosphate 168 lbs.=30 lbs. phosphoric acid ... ... Sulphate of potash 112 lbs.=56 lbs. of potash	15%	...	...	9%	7%	...

These numbers shew that the smaller quantity of manure was insufficient to bring about the greatest development of the plant except in respect of the diameter of the stems. The larger quantity used was probably more than need have been applied.

In addition to the experiments above mentioned a series was arranged in order to determine the value of using lime alone and in conjunction with acid or basic manurial mixtures. The lime was applied one month before the first application of the mixture. In the case of the Burmah plants the use of lime alone has resulted in a slightly increased thickness of stem and height of the plants. When used however with acid or basic manures the results have not been satisfactory and but a poor development of the plant resulted. This is markedly so when used in conjunction with the basic manure.

The result of using lime (see Table XVII.) is more markedly shown in the case of the Singlo plants. When used alone the weight of the plants was considerably increased but when used with

either an acid or basic mixture the plot so treated did not produce plants equal to the check plots. This is more particularly so when used in conjunction with the acid manure.

TABLE XVII.

MANURES, Rate of application per acre.	BURMAH.						SINGLO					
	Diameter.		Height.		Weight.		Diameter.		Height.		Weight.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
Lime 2,240 lbs. ...	2	...	5	..	...	8	...	2	...	4	22	...
Lime 2,240 lbs. ... Sulphate of ammonia 448 lbs.=90 lbs. nitrogen Superphosphate 672 lbs. =122 lbs. phosphoric acid ... ... Sulphate of potash 448 lbs.=224 lbs. potash	4	...	...	9	...	28	...	17	...	28	..	36
Lime 2,240 lbs. ... Nitrolim 503 lbs.=90 lbs. nitrogen ... Basic slag 1,120 lbs.=122 lbs. phosphoric acid ... Sulphate of potash 448 lbs.=224 lbs. potash	...	11	...	6	...	19	...	...	..	6	...	10

A study of the previous tables has shewn that the development of the plants, whether Burmah or Singlo, is very greatly affected by not only the type of manure, that is to say whether it be acid or basic in character, but also by variations in the relative proportions of the ingredients in the same type of manure. This is a most important fact and one that is not sufficiently recognised by planters, since it frequently happens that manures containing more than one of the three important ingredients as for instance fish guano are often applied without any consideration as to whether the mixture is well proportioned. As has been pointed out above unsuitably proportioned mixtures may even check the development of the plant in one or more directions. Although the two varieties of plants behave differently to the same manurial mixture yet in the

case of the acid manures it will be noticed that a mixture represented by the formula :—

Sulphate of ammonia	... ...	112 lbs.
Superphosphate (18%)	... ...	672 „
Sulphate of potash	... ...	448 „

Containing nitrogen, phosphoric acid and potash respectively in the ratio :—

100 : 530 : 1,000

has in all cases proved to be of considerable value although perhaps this is not the best of all possible mixtures.

It will also be noticed that of the acid manures that represented by the formula :—

Sulphate of ammonia	... ...	448 lbs.
Superphosphate (18%)	... ...	168 „
Sulphate of potash	... ...	448 „

which contains the nitrogen, phosphoric acid and potash respectively in the ratio :—

100 : 33 : 250

has given unsatisfactory results.

In the case of the basic manures, no such generalization can be made.

ROOT NODULES.

It is well known that the nodules produced on the roots of leguminous plants are connected with their power of obtaining free nitrogen from the atmosphere and rendering it available for the use of plants. There is, however, some confusion as to the nature of these nodules and the following brief description may be useful to planters interested in green manuring.

The nodules are caused by bacteria which enter the young roots from the soil. The bacteria which occur in different species of leguminous plants present slight differences in form and it has been found by experiment that the bacteria-forming nodules on one host plant frequently fail to infect another plant of a different species. It would appear, therefore, that the species or at any rate the variety of bacteria causing root nodules differs with the host plant. Some legumes when introduced to a new district fail to produce nodules although they may be found on them in abundance in places where they are indigenous. The introduction of soil from the district where the plant usually produces nodules or of cultures of the variety of bacteria found in the nodules, to the soil of the new district, is followed by the normal production of root nodules.

Nodule bacteria have been frequently grown in cultures on gelatine and in solutions, and in that condition they fix nitrogen only feebly if at all. They can indeed exist without free nitrogen so that although a large number of these bacteria may be present it does not necessarily follow that a great deal of nitrogen is being fixed.

The bacteria are only present in the nodules on the roots and if they are introduced to other parts of the plant they merely die. It is by no means certain that the nitrogen assimilation takes place in the nodules. It seems probable that the fixation is rendered

possible by the interaction of the bacteria with the host plant. Chemical substances, formed by the bacteria, and introduced from the nodules into the plant may render possible the assimilation of free nitrogen by the host plant itself.

However, and wherever the assimilation of nitrogen takes place it is certain that the nitrogen fixed is not stored in the nodules, but is used by the plant in the formation of nitrogenous substances necessary to its own development. It is not merely fixed and stored for the use of other plants. The error is commonly committed of supposing that the death of the nodules renders available the nitrogen fixed by the agency of the nodules bacteria. This is entirely wrong. The nitrogen fixed is only rendered available by the death and decay of the tissues of the plant, of which it forms part. The maximum benefit from a green manure crop is only obtained on the death and complete decay of the plants. The idea that most of the nitrogen is in the roots because the nodules are borne on them is erroneous.

A comparison of separate analyses of various parts of leguminous plants shows that with the exception of the seed the highest percentage of nitrogen is found in the leaves. The following figures, taken from analyses of Boga medeloa (*Tephrosia candida*) published in the last number of this journal, serve to illustrate this point:—

			Percentage of nitrogen calculated on dry matter.
Leaves	...	...	3·85%
Stems	...	...	·79%
Roots	...	...	·79%

The leaves and stems usually contain a greater weight of substance than the roots, so that the percentage, in the roots of the total nitrogen of the whole plant, is small.

In this case the total weight of the plant was made up as follows:—

Leaves	...	...	35·72%
Stems	...	...	57·14%
Roots	...	...	7·14%

Calculated from these figures, the leaves, stems and root contribute the following amounts respectively to the total nitrogen of the plant :—

Leaves	...	...	73·26%
Stems	...	...	24·06%
Roots (including r ot nodules)		...	1·68%

It will be seen at once that the nitrogen is not stored in the roots. Hence the idea that the nitrogen fixed by leguminous trees such as sau (*Albizzias*) is rendered available by the cutting of the roots in cultivation is wrong.

The conditions under which root nodules are formed are as follows :—First of all the right kind of bacteria must be present in the soil. Scarcity of available nitrogen in the soil, provided a sufficiency of other necessary constituents be present, favours the growth of these bacteria and the development of root nodules. Leguminous plants growing on soils already rich in available nitrogen fix little nitrogen and the production of root nodules is noticeably restricted. If the host plant be starved in respect of other necessary soil constituents, or injured by disease or other agency, the nodules are reduced in number and size. The growth of root nodules is dependant on the good health of the host plant.

ADDRESS TO DARJEELING PLANTERS.

At an Extraordinary General Meeting of the Members of the Darjeeling Planters' Association, held on 8th August 1914, Mr. A. C. Tunstall, B. SC., the mycologist of the Indian Tea Association, addressed the Meeting as follows :—

In no other tea district is the treatment of fungus blights of such importance as it is here. The climatic conditions are such as favour the growth of fungi and other vegetable organisms injurious to higher plants. Examine almost any tea bush in the district and you will find one or more fungus blights attacking the leaves alone, while the stems are bound up with masses of lichen and moss. It stands to reason that if these unhealthy conditions were removed the plant would give more leaf. Dr. Hope has suggested better pruning, and the application of manure as tending to form a bush better able to withstand the attacks of disease. But however well the plant be pruned, manured, and cultivated, the climate is such that parasitic, and epiphytic organisms will always be present, and will always require additional treatment. At present we know of only one satisfactory way of removing these organisms—by spraying with suitable chemical solutions. In the culture of many other plants spraying has long been recognised as an essential part of the general routine, and it is hardly necessary for me to discuss the desirability of incorporating it with that of tea culture, if labour and other conditions permit.

In former years spraying has been attempted on many gardens but often the machinery employed has been inadequate and in many cases unsuitable, the solutions have been carelessly manufactured, and their application has been wasteful, and defective. It is not surprising that the results have been unsatisfactory, and that many planters have been led to the conclusion that spraying operations in Darjeeling are impracticable.

It is my aim during the next few minutes to shew you a few of the improvements in the machinery, and the methods employed and to convince you that spraying operations are by no means so difficult as one would first suppose. I will first discuss spraying machines. These may be divided into two groups, first barrels or tank machines, and secondly knapsacks.

Barrel or Tank Sprayers:—Sprayers of the first class are not to be recommended, and I will deal with them only to prevent planters buying them and being disappointed in consequence. They consist essentially of a force pump fixed to a barrel, or tank in which the spray solution is placed. The fluid is forced through long rubber hose pipes to the nozzles. These machines possess obvious disadvantages when used in tea. First they are too heavy, and bulky for convenient transport among the tea bushes, secondly the hose pipes are unwieldy and handicap the operator so that it is almost impossible to spray the bushes quickly.

Knapsack Machines:—The knapsack form has so far proved most satisfactory, and it is in these machines that improvement has been most marked. Knapsack sprayers may be divided into continuous pumping and pneumatic machines. The continuous pumping machines are unsatisfactory in that the operator cannot give his undivided attention to the direction of the spray jet. This disadvantage is the more noticeable on hill gardens where the foothold is often precarious and it is desirable to have both hands free. Although this type of machine has been improved greatly of late years I do not advocate its use for the above reason.

I strongly recommend machines of the pneumatic type. At present there are two good machines of this type on the market—the "Alpha" made by Messrs. Robinson Bros., West Bromwich, England, and sold at sixty shillings, and the "Holder" made by Messrs. Hartjen & Co. and sold at sixty-eight shillings and sixpence. I have a specimen of a small machine of the latter type, which has been kindly lent us by Messrs. Shaw Wallace and Co., the agents for these machines. These machines are very simple in construction being merely strong airtight vessels provided with an inlet, outlet, an air valve, and pressure gauge. To charge the machine

the container must be partly filled with the spray fluid, and the inlet closed. Air is then pumped in by a foot pump or in the case of the Holder by a pump attached to the machine, until the required pressure is obtained. This takes a very little time, and all the operator now requires to do is to direct the spray nozzle until the machine is empty. When the machine is opened for re-charging, a quantity of air escapes under the pressure and this means the loss of a certain amount of energy, and a method of avoiding this loss has been found in the "battery" system. In this system there is only one opening which servos as both inlet and outlet. At the commencement of operations the machine is charged with air and the liquid is then forced in against the air pressure. As the machine empties a ball valve closes the aperture, thus retaining the air under pressure, it is then only necessary to pump in more liquid. One large pump which serves a dozen or more sprayers is generally used, but smaller sized pumps may be used with separate machines. The battery sprayer is, I think, the last word in spraying machines. Being absolutely simple, having no small tubes to clog, no fillers or sieves to give trouble, and few wearing parts to get out of order, it is undoubtedly the best type of machine on the market. At present the best battery machine is the "Holder" a modification of the Holder pneumatic sprayer. Each sprayer with accessories costs three pounds, six shillings, and six pence, while the central charging pump, which may be used for any number of sprayers, costs nine pounds, fifteen shillings. The "Alpha" makers, are I understand placing a battery sprayer on the market shortly.

The materials of which the machines are constructed must be such as to resist the action of any spray fluid likely to be used, and this should be borne in mind when ordering spraying machinery.

Cleaning Spraying Machines :—It would seem hardly necessary to point out that spraying machines must be carefully cleaned at the close of each day's work, but I have frequently seen this neglected. The metal parts may be able to resist the action of a low percentage solution, but not one of higher concentration. If drops of solution be allowed to stand in the machine evaporation takes place, and the solution concentrates, often attacking the material. This is of extra importance in the case of pneumatic

machines, as the container may be so weakened as to burst, and possibly cause serious damage to the operator.

Fineness of Spray Nozzle :—An important point is the fineness of the spray jet produced. It should hang over the bushes like a mist, it can hardly be too fine. It then settles on the leaves and stems covering them with a very thin film. If the jet is too coarse the fluid will collect in drops leaving dry spaces between, and much more fluid is necessary to completely cover the plant.

Preparation of Spray Fluids :—The spray fluids must be carefully prepared if satisfactory results are to be obtained. Many of the more useful fluids may now be obtained in concentrated form, and in cases where their local manufacture is found difficult it would probably pay to go to the extra expense of buying them ready made.

I have a sample of Woburn Bordeaux paste here which is an excellent example of a preparation of this kind. This paste when mixed with water is an efficient substitute for Bordeaux mixtures. It costs twenty-five rupees per cwt. in Calcutta. One cwt. is sufficient for 800 gallons of spray solution. As many of the preparations of this type on the market are unsatisfactory it is advisable to consult the Scientific Department before buying any particular one in quantity.

I will not here give specific instructions for the manufacture of spray fluids as they will shortly appear in the pamphlet on spraying which as you are aware will be published later in the year.

Supply of Fluid :—The organisation of the supply of fluid for machines at work in the tea is of great importance. To reduce the labour to a minimum requires very careful supervision.

The number of bushes which a sprayer can do at one filling may be found by experiment. The day's work may then be calculated out before hand so that the solution is always in the right place, and no time is lost in unnecessary walking about.

Carrying the solution from the factory to the tea in tins or barrels has been the usual procedure in the past, and when operations are on a small scale it works very well; but when hundreds

of acres are to be treated it is necessary to find a cheaper way. On some gardens well supplied with water it has been found advisable to place tubs at intervals in the tea. These tubs when filled up to a mark with water contain a known volume. Packets or bags each containing the correct amount of chemicals necessary for one tub of solution are weighed out at the factory. In case of chemicals which take a long time to dissolve, such as copper sulphate, it is better to make up strong solutions of a definite concentration and put these in bottles or earthenware vessels—a measure holding the correct amount for one tub being supplied.

Permanent Pipe Lines :—In some gardens it may be desirable to lay down permanent pipe lines, to central positions in the tea. A flexible hose could then be attached to a tap, and the water conveyed direct to portable tank.

Motor pumps:—On less compact gardens the provision of a small portable motor pumping outfit with a portable pipe line would be more desirable. For some time I have been corresponding with various engineering firms about suitable outfits, and in a short time I hope to be able to test some of these. Their cost is small compared with the labour saved.

Preserving iron tanks:—If iron tanks or tins are used for spray solutions the iron must be protected from their action by a coating of some kind, otherwise the solution will be affected, and in some cases rendered useless. There are one or two good preparations for the purpose on the market.

Dry powders:—There are some places where at certain seasons of the year it is almost impossible to obtain water in sufficient quantity for spraying operations. In these somewhat rare cases I would recommend the use of dry powder instead of solutions. These are best applied by dusting machines. I have two excellent examples of this type of machine here—"Holder Dry Duster" and the "Mollenkamp" each costing Rs. 30/- in Calcutta. Powders as a rule are not so effective as solutions.

These dusting machines may be used also for the distribution of artificial manures.

Capital cost of spraying Machinery:—The initial outlay for good spraying machinery is considerable, but including sprayers, tanks, motor pump, and pipe lines, the capital cost for a 500 acre garden would not exceed Rs. 3,000/-.

Cost of spraying:—The cost of making one application of Bordeaux mixture is under Rs. 3/- per acre. Soda solution costs considerably less.

Treatment suggested:—I would suggest that in this district all cleaned out tea be sprayed with soda solution immediately after pruning. This will remove the mosses and lichens which restrict the flow of sap. At about the same time the unpruned may be sprayed with Bordeaux mixture. A second application of Bordeaux mixture should be made this time to the whole area, after the first flush has been removed. The average yield per acre of tea in this district is at present very small and there is every reason to suppose that a combination of scientific manuring, pruning and spraying, would very considerably increase it without affecting the quality. All garden relations are interdependent and I am not suggesting that spraying is all that is necessary to reduce or remove blights. It is only one of the necessary components of the general routine. There are some gardens in this district where the carrying out of spraying operations would be analagous to giving a sick man medicine while unable to give him proper food. On such gardens improvements in other directions are necessary before general spraying is attempted. There are however many gardens, and their number will increase every year, where it is possible to incorporate spraying with the general routine without interfering with other operations.

The initial outlay and the running expenses of spraying operations are not high when one considers the probable benefits to be obtained. Again consider the present state of unpreparedness of tea gardens not only here ; but in other districts also. Suppose a really serious blight appeared—a blight which not only attacked the leaves but killed the whole plant, and spread with the rapidity of blister blight. How could it be checked ? The apparatus at present avail-

able would be as a single bucket against a forest fire. The provision of adequate machinery for the treatment of plant disease is a *form of insurance* which should on no account be neglected.

NOTE.

A number of firms are now paying special attention to the needs of tea gardens and it is probable that marked advances will be made. Since the address was delivered information has been received that the "Holder" and "Mollenkamp" machines are of German manufacture. Similar machines but of British manufacture have now been placed on the market by Messrs. Hartjen & Co., under the name of "Holder—Harriden" machines. Machines exactly similar in all respects to the Holder machines but entirely British are now manufactured by the "Four Oaks" Spraying Machine Co., Four Oaks Works, Sutton Coldfield, Birmingham, and sold at the same prices.

Messrs. Robinson Brothers have now prepared an improved "Alpha" machine. Various firms are also placing improved battery sprayers on the market.

Information has been received from America of large power dusting machines which claim to treat 50 to 60 acre of fruit trees each per day. It is possible that the use of such machines in tea would effect a great saving in labour.

RECENT TOURS.

Chief Scientific Officer.

At the beginning of September the Chief Scientific Officer continued his touring programme and proceeded to North Lakhimpore, a district which he had never previously visited. The time at his disposal was, however, too short to permit of visits to every garden.

In this district each garden undoubtedly presents very marked individual features as regards the nature of the soils. Some of the sandiest tea soils are in evidence here while in other cases the soil is a rather stiff intractable loam such as is found in certain districts in middle and lower Assam on the South Bank of the Brahamaputra. Occasionally bands and patches of this loam run through gardens of which the soil is in general very light and sandy. On the sandy soils of these districts green crops and shade trees should be used with caution on account of their effect in robbing the soil at certain times of year of its moisture, which in such soils is present in small quantities only. In dry weather or in dry spells during the rains the removal of water by green crops and shade trees may interfere seriously with the supply which is available for the tea bushes.

Organic matter is very seriously required on most of these soils, in order to make them more compact and to increase their power of retention of moisture and of soluble food substances, but it should be supplied as far as possible by other means than that of green crops and shade trees, though the supply of suitable substances for this purpose is usually so small that to a certain extent the latter means must be made use of.

Lime should be used with caution on these soils though it will be found necessary in small quantities on most of them. It should be supplied in small quantities only and preferably in the form of ground limestone. On sandy soils in this as in other

districts the framework of bushes does not appear to have the same vitality after the tea has reached a certain age as it has on soil of a more clayey type, such, for instance, as those of the Red Bank. Consequently pruning with a view to renovation of frames is a matter which requires careful attention and skilful manipulation, and heavily cut back tea should always be liberally manured with all-round mixtures. The bushes growing on the sandy soils of North Lakhimpore share with those growing in other sandy districts susceptibility to attacks of root fungus, and planters who have to deal with such conditions should be constantly on the watch for appearances indicative of this class of disease. The heavier soils of this district usually require addition of organic matter, and green cropping and the growth of shade trees is in this case the most practical means of adding it to the soil.

An address which was attended by six planters was given at the bungalow of the Sub-District Chairman and visits were paid to three gardens.

Owing to the unpunctuality of river steamers arrival at Bishnath was delayed beyond the scheduled date and beyond that for which the Sub-District Chairman had arranged a meeting of planters. Consequently the visit to this Sub-District was postponed.

The Chief Scientific Officer arrived in Tezpore on the 20th of September and left on the 26th, having given an address which was attended by ten planters on the 23rd at the bungalow of the Sub-District Chairman. Owing to the ease with which one garden can be reached from another in this district he was able to visit nine gardens during the time at his disposal. The Tezpore District is one which presents great contrasts, chiefly as regards the soil and methods of work. The majority of gardens in the District are situated on the Red Bank, and though this soil differs considerably from garden to garden most of those situated on it can be said to have very satisfactory soil conditions. The importance of good cultivation and drainage and frequent green cropping on these soils may be emphasised here. A noticeable feature of the Red Bank soils is that they are much more responsive to organic, nitrogenous and phosphoric manures than are other tea soils which

must be placed in the same category when judged from physical data.

The soils in this district which are not on the Red Bank present more difficult problems, but those which are light in character have the advantage of being more responsive to manurial treatment and easier of cultivation.

A very noticeable feature in this district is the different attitude which is adopted towards the question of pruning. On some gardens renovation of frames has been carried out over nearly every section of tea and the bushes are now in a condition such that, with careful light pruning (this term is used in the sense indicated in our recent pamphlet on pruning) the bushes should yield well for many years, if not indefinitely, without more drastic treatment, so that every section is from the point of view of pruning in a condition to continue to yield its best possible crop. On other gardens the policy has been adopted of treating the bushes as leniently as possible both in plucking and in pruning, while at the same time treating them very liberally as regards cultivation, and consequently the bushes look at present in the best of health, but serious difficulties would have to be faced if it were necessary to make greater demands on them. Renovation would then have to be carried out by means of pruning and this would have to be faced in respect of a very large part of the total area and might be necessary at a time when market conditions are very different from at present. It appears to us that the present is the time to effect necessary renovation which can now be carried out without serious strain on annual profits.

The Chief Scientific Officer arrived in Mangaldai District on the 28th being delayed for one day at Gauhati. He had not visited this district previously. He gave an address at the Panery Club which was attended by nine planters and visited six gardens in the district. This district is probably capable of producing as big a crop per acre as any in North East India. Thirteen maunds per acre over the whole garden is the actual average of one garden. Soils in this district differ considerably from garden to garden. Immediately under the hills they appear to approximate to those

of the Red Bank. Away from the hills they are usually sandy in character and in one case complication arises by the incursion of fine black river silt. It is noticeable that although the most harmful pests and blights did not appear to be known in this district yet those of minor importance are present in great variety. Planters in this district should be on their guard against them and should be on the lookout for the arrival in the district of those of a harmful nature.

On the 4th of October, the Chief Scientific Officer left the district and returned to Tocklai where he remained for most of the month, proceeding to Calcutta on the 27th. On the 21st of November he returned to Tocklai accompanied by Mr. H. R. Cooper, the newly appointed Second Assistant Scientific Officer.

On the 26th of November he proceeded to Tezpore accompanied by the Assistant Scientific Officer for the purpose of attending the Annual General Meeting of the Assam Valley Branch of the Indian Tea Association. He returned to Tocklai on the 29th.

On the 13th of December the Chief Scientific Officer left Tocklai for Bishnath to pay the advisory visit postponed from September. He visited six gardens in the district and addressed a meeting of eleven planters at the Bishnath Club on the 16th. He left on the 20th for Tocklai. On one of the Red Bank soils of this district he was shown a very interesting and successful example of the formation of bushes from young plants by employing plucking as distinguished from pruning as the method of training the seedlings into bush form. It appears that this method can be carried out with eminent success on certain classes of soil and of seed. In this case Red Bank soil and Manipuri bushes. This method is less likely to be successful on the sandier soils of the district. A noticeable feature of the latter type of soil is its poverty in respect of plant food substances. Several gardens on this type of soil in this district require heavy manuring. Since many of these soils are near rice land level, it is noticeable that when the immediate subsoil is of a clayey character the tea appear to be suffering from water-logging. Deep and close drains are necessary in such cases.

Entomologist.

During August, September, and October the Entomologist toured in Cachar in connection with the mosquito blight enquiry. A comparison of observations made during this and previous tours shows that gardens in this district may be considered under three heads :—

1. Those which are not seriously affected, even though climatic and other conditions seem to favour the development of the insect.
2. Those which are seriously affected in some years, and hardly at all in others.
3. Those which are always seriously attacked, even when neighbouring gardens are almost free.

The season 1914 may be said to have been climatically unfavourable for *Helopeltis theivora* in Cachar, and in the district as a whole mosquito blight was less serious than usual. Gardens which come under heading, number (2) above, were practically free from blight, but many gardens which come under heading number (3) were, if anything, worse than usual. Examination of some of the latter gardens afforded indications that at certain times growth had been so slow that all the young shoots had been nipped while in the bud stage, the damage done being due, not to an extraordinary large number of the insects, but to the fact of the bushes having remained more or less at a standstill while the tea mosquito had gone on steadily feeding and breeding in the ordinary way. A section of one garden had suffered from an exceedingly virulent type of attack. It was badly hit by hail twice towards the beginning of the season, and was robbed of the opportunity of making growth before *Helopeltis* become sufficiently numerous to produce much effect on the bushes. The few shoots put forth after "tipping" were immediately attacked to such an extent that the original stems were affected throughout their whole length. In many cases the whole of the season's growth died off, and in cases where the shoots were not yet dead, the inside was found to be blackened for several inches down. Not far away, on a neighbouring section, were bushes which, though punctured, had scarcely

suffered, and had made growth and given leaf. This preference of the insect for certain bushes appears to be a great controlling factor in mosquito attack, in Cachar at any rate, and the distribution of mosquito blight throughout the district can only be explained on the supposition that certain bushes possess some peculiar feature which renders them less liable to attack the others, and that the percentage of bushes liable to attack, and the degree of liability of each, determines the position of a garden in the rough classification given above.

If then any difference can be found between the bushes which are liable to attack and the others, and if the soil conditions which bring about this difference can be discovered, it may be possible to put forward some method of treating the soil by which the pest can be controlled, and experiments are being conducted on lines calculated to throw light on this subject. Analyses of some twenty soils from North Cachar show that, from a purely analytical standpoint, these soils may be separated into two distinct groups, in one of which the bushes are liable to mosquito blight, while in the other they remain comparatively free. Whether similar relations exist in other districts remains to be seen.

It is interesting to note that the floods of 1913, although they produced differences in the distribution of mosquito blight at the time, appear to have had little, if any, permanent effect, and it appears probable that the difference was entirely due to the insects having been carried about by the water. That this explanation is feasible is shown by experiments carried out during the tour under notice, in which *Helopeltis* was found to be capable of surviving an immersion in water of about ten hours. In one case a damaged adult female came round and began to feed after being entirely submerged in water for thirteen hours.

At the beginning of November the Entomologist commenced an advisory tour in Sylhet. The first district to be visited was the Chargola Valley, where mosquito has in some places attained serious proportions. The Entomologist was there from the 4th to 8th of the month, and was able to discuss questions of entomological interest with most of the managers in the district while going round

the gardens. The period from the 9th to the 13th was spent in the Longai Valley, in which a similar programme was carried out. One garden in this district furnished an interesting illustration of the effect of shade trees in tea. At the time of the Entomologist's visit the blighted parts of gardens had been black from some time, and the tea mosquito had begun to fall off in numbers. It is normally found, at this time, that a few shoots will come through, but in consequence of the drought, which was causing all places in the district to close up rapidly, the leaf was not coming through as usual. On one flat, planted with Koroi trees, which as a whole was black with mosquito blight, it was noticeable that the bushes under the trees were giving leaf, and the only explanation of this seems to be that the trees, by opening up the soil below and by the shade they gave, had afforded a certain amount of protection from drought to the bushes in their immediate vicinity. The Entomologist next visited the North of Surma district, and discussed the questions of Red Spider and borers with managers, these being the only insect pests of importance. On the 19th a meeting of planters of the Lungla Valley was held at Rajnagar Tea Estate, and the treatment of Mosquito Blight and Red Spider was discussed. Seven planters attended. On the 20th a short lecture was given at Ruthna Tea Estate on the subject of insect control in general, and of Mosquito Blight and Red Spider in particular. Eight planters from the Juri Valley were in attendance, and a discussion of some length followed. Next day (the 21st) an address was given to the planters of the Doloi Valley at Kurmah Tea Estate, on the subject of insect control, succeeded by an interesting discussion dealing mainly with Termites and Red Spider. On December 4th the Entomologist visited the Balisera Valley, the intervening period having been spent at Tocklai, and on the 5th an address was given at Balisera Club on the treatment of White Ant and Red Spider, at which thirty-nine were present. The tour is proceeding.

NOTES.

Some South Indian Insects:—We have received, through he courtesy of Mr. T. Bainbrigge Fletcher, R. N., F. E. S., a opy of a book which we recommend to the perusal of planters nterested in the Entomological side of their work. This book s entitled "Some South Indian Insects and other animals f importance considered especially from an economic point of iew," and containing as it does nearly six hundred pages of etter press, with fifty coloured plates and four hundred and orty text figures, is of marvellous value at six rupees. This ook, as its title implies, deals, for the greater part, with insects rom Southern India, but about half the text is devoted to the onsideration of questions of general economic importance. In the irst three chapters, the author essays the difficult task of dealing in popular manner with the structure, classification, and life histories f insects in general. These are followed by chapters on such subjects s the relations between insects and pests, response of insects to timuli, parasitism, etc., all of which have often to be considered vhen devising means for combating insect pests. Chapter XI deals vith general methods of insect control, which are considered under he four heads agricultural, mechanical, insecticidal, and special, and ontains useful information on insecticides, spraying machines, nd the modification of agricultural practices for the prevention and melioration of attacks. The author then goes on to describe the arious pests of plants group by group, and ends with a classified ist of the principal crop pests of Southern India, giving under each ts distribution, life-history, food plants, and status as a pest, and nethods for its control. Two features of the book are, a list of rops with the insects which attack each, and a list of allied food plants of insect pests, which greatly facilitate reference.

O. P.—1100—28-3-1915.

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